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An early Brunhes (<0.78 Ma) age for the Lower Paleolithic tool-bearing Kozarnika cave sediments, Bulgaria

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ABSTRACT

We present a new sedimentological profile and a magnetostratigraphy of the tool-bearing Kozarnika cave sediments from Bulgaria. Modal analysis of cave infilling sedimentary texture indicates that the tool-bearing layers contain a sizable fraction of sediment interpreted as loess. We also find evidence for a relatively thick and well defined normal magnetic polarity in the upper-middle part of the section interpreted as a record of the Brunhes Chron, followed down-section by reverse polarity directions interpreted as a record of the Matuyama Chron. The lowermost levels with Lower Paleolithic tools (Layers 13a–c) lie in the early Brunhes at a nominal maximum age of ~0.75 Ma, while the Brunhes–Matuyama boundary (0.78 Ma) falls in Layer 13 Lower immediately below. This finding represents a conspicuous revision of previous age estimates for the same tool-bearing layers.

1. Introduction

The Kozarnika cave (Sirakov et al., 2010 and references therein), located in northwestern Bulgaria (Fig. 1) at the margin of the Danube loess basin (Haase et al., 2007), is the repository of a 9 m-thick stratigraphic succession containing lithological units (Ferrier et al., 2009; Sirakov et al., 2010) labeled from Layers 3–4 at the top to Layer 14 at the bottom (Fig. 2). This sequence hosts various archaeological complexes spanning from the Neolithic (and younger) at the top followed downsection by a blade industry termed Kozarnikian, then Middle Paleolithic and Lower Paleolithic industries (Fig. 2) (details in Guadelli et al., 2005; Sirakov et al., 2010).

The upper Layers 3–10b yielded radiocarbon and optically stimulated luminescence (OSL) ages broadly spanning from 13.2 ka to 183 ka (ka = kiloannum = one thousand years ago) (details in Guadelli et al., 2005; Tillier et al., 2017; see also below). Large mammal biostratigraphy seems to indicate that Layers 11b to 13c should belong to Mammal Neogene/Quaternary (MNQ) zones 19 to 17 with an attributed age of ~1.4–1.6 Ma (Ma = megaannum = one million years ago) (Guadelli et al., 2005; Sirakov et al., 2010; but see Popov and Marinska, 2007 for an alternative interpretation). These mammal age assessments are however potentially marred by the lack of continuity of the Kozarnika sequence, which seems to consist of an intermittent succession of sedimentary episodes and phases of human occupation (new studies are underway to contribute resolving these uncertainties in key Layers 10c–11c).

A preliminary magnetostratigraphic investigation of the cave sediments (Sirakov et al., 2010) indicated that sediments down to the middle part of Layer 11b are characterized by normal polarity magnetization interpreted as a record of the Brunhes Chron (base at 0.78 Ma; time scale of Lourens et al., 2004). Low magnetic inclination values in the lower part of Layer 11b were tentatively

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Fig. 1. Map of northwestern Bulgaria with location of the Kozarnika cave (43°39′ N, 22°44′ E).

interpreted as indicating transition to reverse polarity of the Matuyama Chron, but problems of consolidation of blocks did not allow to retrieve a continuous paleomagnetic signal (Sirakov et al., 2010). According to these preliminary data (Sirakov et al., 2010), the lower archaeological levels with lithic tools would predate the Brunhes–Matuyama boundary (0.78 Ma).

Encouraged by this earlier attempt, here we report a thorough magnetostratigraphic study of the cave sediments from Layer 5 to Layer 14 coupled with a novel interpretation of the genesis of cave sediments. These results will be used to assess the stratigraphic continuity of the Kozarnika cave sequence and provide an age assessment for the lowermost levels bearing Lower Paleolithic tools.

2. Geological setting

2.1. Cave stratigraphy and sedimentology

The Kozarnika cave opens to the south at an altitude of 481m on a northern hillside of a tributary valley of the Skomlia River, at about 85 m above the valley floor (Sirakov et al., 2010). The Skomlia valley is about 185 m deep and cuts through a Jurassic sequence comprised of Early Jurassic red conglomerates, Middle Jurassic yellow limestones and Late Jurassic grey limestones that host the cave (Ferrier et al., 2009). The stratigraphy of the Pleistocene cave infilling, updated after Sirakov et al. (2010), is comprised of the following set of main layers described from top to bottom (Fig. 2; see also Ferrier et al., 2009; Sirakov et al., 2010):

- Layers 3a to 4 constitute the uppermost part of the sequence and have not been sampled for magnetostratigraphy. They are altogether 1–1.4 m-thick and composed of calcareous clasts (coming from the cave walls and ceiling) in a light brown to whitish silty matrix. These layers contain archaeological levels IVb-0I attributed to middle and recent stages of the Kozarnikien, which is a local blade industry containing backed pieces. Calibrated radiocarbon ages were obtained from uppermost Layers 3a and 3b spanning from 13.2 to 24.5 ka (Guadelli et al., 2005) (Fig. 2).
- Layers 5a to 10c are altogether about 1.2–1.5 m-thick. The upper part of this sequence (Layers 5a to 10a), is characterized by yellowish brown silts embedding calcareous clasts and blocks resulting from the fragmentation of the cave walls and ceiling. Underlying Layers 10b and 10c consist of loose dark-brown loamy sand containing gravels and calcareous pebbles showing variable degrees of weathering. In this sequence, Layers 5a-c yielded archaeological levels V–VII attributed to the early stages of the Kozarnikien, and Layer 5b yielded a calibrated radiocarbon age of 31.2 ka (Sirakov et al., 2010) (Fig. 2). Layer 6/7 includes archaeological level VIII, which corresponds to an industry regarded as characteristic of the Middle Paleolithic and the initial Late Paleolithic; it also yielded uncalibrated radiocarbon ages ranging from 42.7 to 43.6 ka (Sirakov et al., 2010) (Fig. 2). Layers 9a to 10a contain archaeological levels IX-XIII attributed to the Middle Paleolithic (Mousterian) while Layers 10b and 10c contain the lower end of the Mousterian sequence. Layer 10b was recently dated with optically stimulated luminescence (OSL) from 128 to 183 ka (Tillier et al., 2017) (Fig. 2).
- Layers 11a to 13c have a total thickness of about 2.5 m and are composed of rather compact yellowish brown loamy sediments, blotched with dark manganese-bearing nodules and more or less rich in rock blocks and pebbles (limestone blocks, flint pebbles from the cave walls, and more rarely rounded pebbles of quartz) with high degrees of alteration. These layers contain Lower Paleolithic core-and-flake, non-Acheulian industries.
- Layers 13 Lower to 14 represent the section base and are characterized by abundant limestone boulders with occasional yellowish brown, laminated sandy matrix in between. Archaeological artifacts have thus far not been recovered from these layers.

2.2. Grain size analysis of cave sediments

Grain size analysis was performed on Layers 9–14 to elucidate the origin of the cave sediments (Gale and Hoare, 1991). A total of 14 samples, ranging in weight from 25 to 40 g, were treated with 10 ml of 30% H_2O_2 in order to remove any organic matter content. This treatment was repeated twice. After drying in an oven at 50 °C, samples were gently disaggregated in an agate mortar and sieved at 1000 and 500 μm. Samples were weighted after each step. The <500 μm fraction was then dispersed in 0.05% sodium metaphosphate solution, disaggregated in an ultrasonic bath for 15 s, and then passed through a Malvern Laser Particle Size Analyser